LOGANEnergy Corp.

Initial Report FY'01 CERL PEM Demonstration Program

Fort McPherson PEM Project

Atlanta, GA

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Introduction

Fuel Cells convert the chemical energy of a fuel into useable electric and thermal energy without an intermediate combustion or mechanical process. In that respect, they are similar to batteries. However, unlike batteries, fuel cells oxidize externally supplied fuel and therefore do not need recharging. Ever since National Aeronautics and Space Administration (NASA) adopted fuel cell power for the Apollo Space program, American industry has been fascinated by the prospects for their use on earth as well.

When integrated with a fuel processor and a solid-state power conditioner, the fuel cell power system becomes one that produces clean, quiet and reliable electric power and heat. Several manufacturers are currently hard at work to translate the basic technology into consumer products. As advances in PEM technology and mass production converge to introduce competitively costs systems into the marketplace, many are betting that small-scale fuel cell generators will soon be ready to tackle thousands of residential and small-scale commercial power applications. These new appliances will be packaged energy systems providing both heat and electricity that will be able to operate with or without the local utility grid.

Until recently, however, the promise of fuel cell technology has been slow to advance beyond a narrow beachhead commonly referred to as the "early adopter" marketplace. Broader market appeal has been constrained by fits, false starts and premature expectations raised by eager manufacturers; but also high prices, skepticism, and not a little resistance by parochial interests have all restricted the opportunity. Notwithstanding, during the decade of the 1990s, the UTC PC25C Fuel Cell program, assisted by a significant DOD investment, gradually established a solid record of achievement and customer satisfaction at numerous US locations and around the world. Installations sites included military hospitals, commercial buildings, banks, food processing facilities, data processing centers, police stations, and airports.

While many of these "early adopters" hosted pure technology demonstration projects, the industry gained valuable experience and knowledge because of them. More recently, however, customers have warmed to the proposition that fuel cells have real performance advantages in various combined heat and critical power applications (CHP). Perhaps their attitudes and business practices may be adjusting to accommodate an uncertain energy landscape. Clearly, many energy providers are scrambling to maintain their market base, others are floundering, and still others are stalking new opportunity. Nevertheless, they are all discovering that informed consumers have gained new leverage through the power of choice. Increasingly, newspaper articles, periodicals and other media outlets are scoring direct hits with stories about fuel cells. Policy makers are out front raising expectations of a cleaner, highly efficient fuel cell/hydrogen based economy of the future. The signals are clear. Initiative and momentum are driving a rapidly maturing fuel cell industry.

Certainly one reason is because fuel cell technology represents, perhaps, the most exciting and innovative development in the energy industry today. In some ways the technology is maturing more rapidly and markets are developing more quickly than the supporting infrastructure, codes and standards are able to accommodate. However, as technology demonstrations increasingly give way to CHP fuel cell installations that provide practical solutions to demanding consumer requirements, such roadblocks should get resolved as consumer and utility interests find common ground. For example, in most applications, large-scale fuel cell installations may off-load significant power resources during critical grid demand intervals, serving utility interests, while providing "hot" back-up for mission essential loads in commercial and even residential applications. Additionally, they may also provide Btus for heating and cooling loads-demonstrating the dual benefits of enhancing grid stability and promoting energy conservation.

At the small scale and residential end of the fuel cell spectrum, the opportunity is just as promising for the rapid expansion of distributed power generation. Conceivably, thousands of 3kW to 5kW CHP fuel cells in homes and small businesses across the country could within several years displace hundreds of MWhs of electricity and millions of Btus with clean, efficient and reliable energy service. If this occurs, it could have a dramatic impact on both the energy industry, and on the nation's economy and security. Consumers, not utilities, could begin displacing environmentally disruptive generation methods, thereby forcing changes in the industry. As providers of grid resources, they may one day collectively enhance grid stability in many areas, boosting efficiency and conservation norms, and having a decided impact on the evolution of national energy policy.

Against this backdrop, the US Army Corps of Engineers Construction Engineering Research Lab (CERL) has contracted with LOGANEnergy through its FY'01 PEM Demonstration Program to engage a progressive fuel cell energy strategy to inform future DOD policy and planning. Broadly speaking, this engagement directs LOGAN to purchase and install residential and small-scale fuel cell power plants, and then test and evaluate their performance in widespread applications at selected military installations. Three events make this program very timely. They are (a) the complexities and perplexities of utility deregulation juxtaposed with, (b) base utility privatization programs, and (c) the nascent interest in distributed generation / CHP technologies that promise more efficient utilization of resources.

If the fuel cell industry appeared very much ahead of a languid power market in the recent past, today those markets are in comparative turmoil. Prices and availability, in some cases, are volatile and beyond the comprehension of energy managers and consumers alike. Consumers who are seeking innovative and efficient energy solutions for greater comfort, convenience and reliability are adding a new urgency. If the fuel cell industry can capitalize on these conditions, it will have a rich market opportunity, but it will have to deliver energy services and benefits that are immediate, site specific, cost effective, energy efficient, and certifiably green!

In order to test and evaluate the state of PEM fuel cell technology against these challenges, LOGANEnergy Corporation will demonstrate over the course of a year a PEM small-scale fuel cell at Fort McPherson, GA, home of the US Army Forces Command. The project will be guided by an operations plan that will direct the installation, testing, evaluation and reporting on the performance of the unit. The objectives of the plan include;

1. Evaluating installation methods in order to help standardize safe and cost effective installation practices,
2. Evaluating "out of the box" reliability and interoperability with existing facility electrical and mechanical systems / infrastructure,
3. Evaluating actual PEM operating characteristics as compared to manufacturer representations,
4. Measuring the cost of operating a PEM unit under real market conditions,
5. Measuring, collecting and analyzing operating data including, total load hours, availability, kW production, fuel consumption, water consumption, forced outages, serviceability, and manufacturer's support.
6. Introducing PEM technology, power distribution and energy efficiency to DOD and local stakeholders in the community.

The project will be led by LOGANEnergy and supported by the Fort McPherson Directorate of Public Works, Plug Power and Energy Signature Associates.

Fort. McPherson, GA PEM Site Selection and Installation

Figure 1, Demonstration site in Fort. McPherson Historic District

The first contact with representatives of FORT. McPherson occurred in March 2002. At that time Sam Logan of LOGANEnergy met with Mr. Luke Wyland and Mr. Graham Parker PNNL, to discuss whether Fort. McPherson had an interest in developing a fuel cell demonstration project on the base.

Subsequent discussions led to consensus for submitting a proposal to CERL to host a PEM Demonstration project. LOGAN advised CERL of the opportunity and in May 2003 LOGAN received a modification to its existing DACA42-02-C-0001 contract that provided additional funding to include Fort McPherson in its FY'01 PEM program. After reviewing several possible sites on the base, the home of Lt. Col and Mrs. Luster, Figure 1, above, was selected to host the installation.

In June 2003, representatives of CERL, LOGAN and Fort. McPherson held the project kick-off meeting. In July 2003, Plug Power shipped the unit, S/N 199, to Fort McPherson, where it was placed on its pad, as seen in Figure 2, at right. The site is the oldest building on the base, circa 1880. Additional photos below document the several tasks involved in the installation of the project.

Figure 2, Location View

Figure 3, Fuel Cell Pad Site

Figure 3, to the left, shows another photo of the unit on its pad. The gray box in the background houses the DI/RO water supply panel as well as the RTU, which provides Web connectivity to the site.

Figure 4, at right, is a close up of the equipment housing mentioned above. The photo also shows the installation of both the fuel cell electric and natural gas meters.

Figure 4, Natural Gas & Electrical Interfaces

Figure 5, at right, shows the method of providing fuel cell waste heat with the existing hot water tank. The "U" shaped coil is a Heliodyne Heat Exchanger mounted on the wall adjacent to the tank. Other components include:

Expansion Tank

Circulating Pump

Emergency Panel

Normal Service Panel

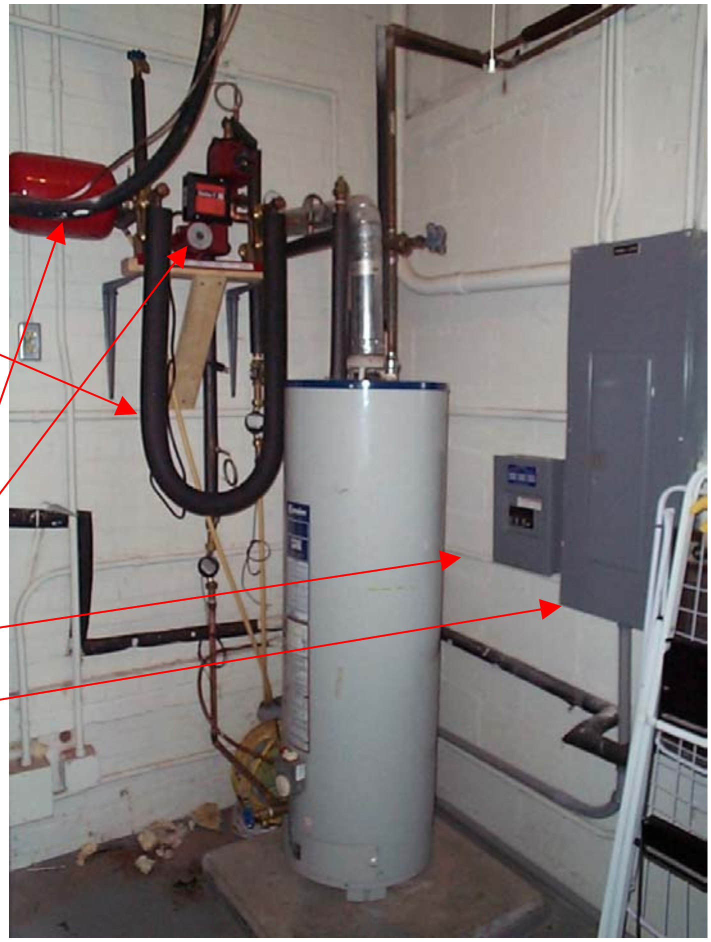


Figure 5, Thermal Recovery Package

Figure 6, Instrumentation and RTU Housing

Figure 6, at left, displays a photo of a LOGAN fuel cell technician connecting instrumentation wiring to the RTU terminals that will transmit operating and performance data via a VPN to LOGAN's distributed generation control center in Rochester, NY. The data will be available for general public viewing at https://www.enerview.com/EnerView/login.asp
Login: logan.user
Password: guest

Installation Line Diagram

Fort McPherson PEM Installation Line Diagram

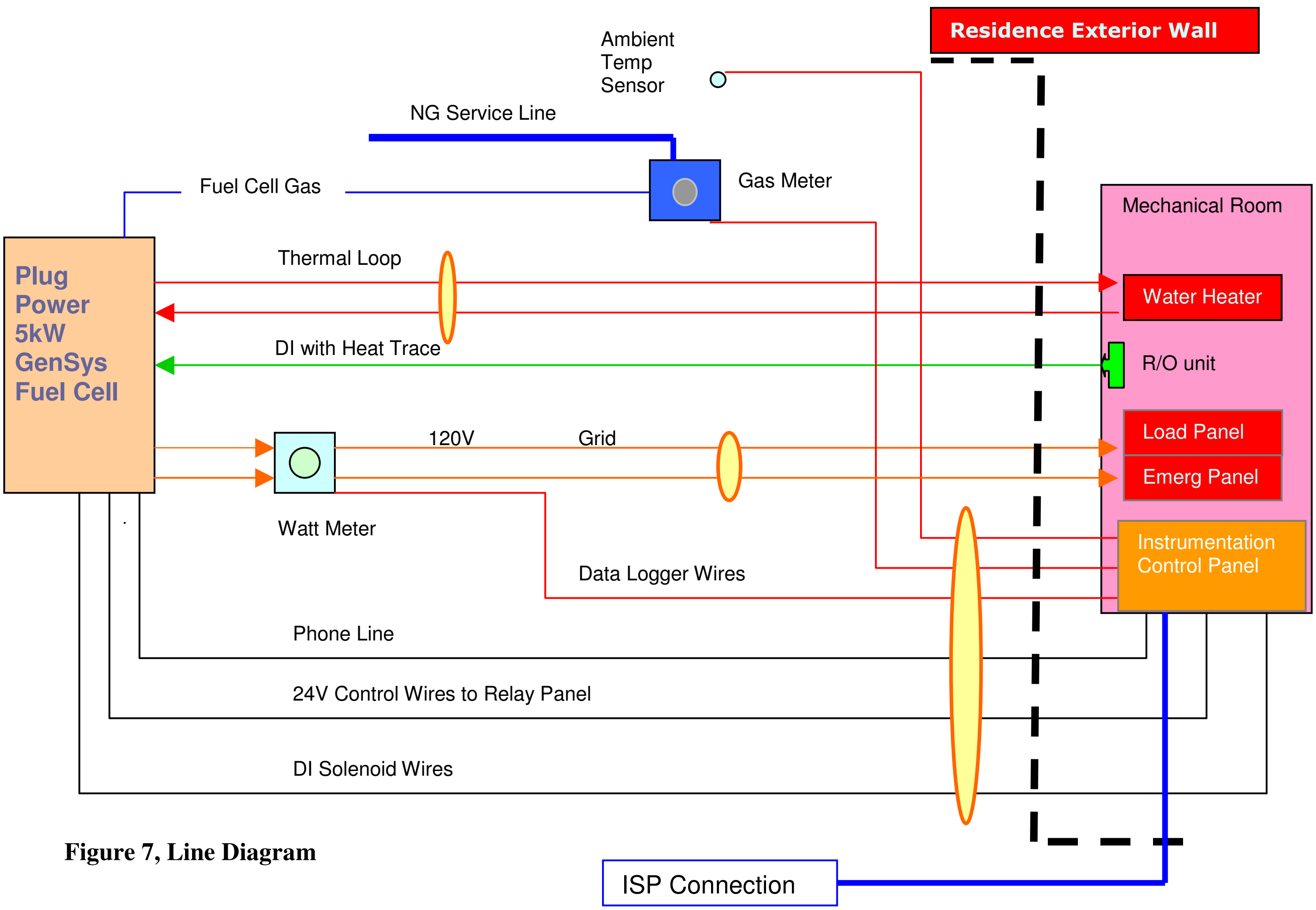
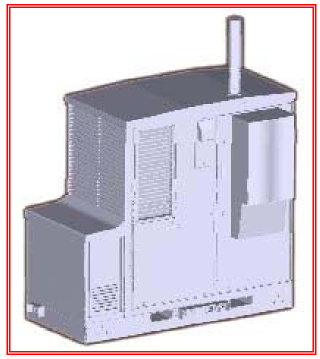


Figure 7, Line Diagram

GenSys5C Product Specifications

Plug Power Fuel Cell System

The GenSys5C is a 5kWAC on-site power generation system fueled by natural gas. Designed to be connected to the existing power grid, the 5C is a clean and efficient source of power.



Specifications

Physical	Size (L X W X H):	84 1/2" X 32" X 681/4"
Performance	Power rating:____	5kW continuous
	Power set points:____	2.5kW, 4kW, 5kW
	Voltage:____	120/240 VAC @ 60Hz
	Power Quality: ____	IEEE 519
	Emissions:____	NO_X < 5ppm
		SO_X < 1ppm
		Noise < 70 dBa @ 1meter
Operating Conditions	Temperature:____	0°F to 104°F
	Elevation:____	0 to 750 feet
	Installation:____	Outdoor/CHP
	Electrical Connection:____	GC/GI
	Fuel:____	Natural Gas
Certifications	Power Generation:____	CSA International
	Power Conditioning:____	UL
	Electromagnetic Compliance:	FCC Class B

Dimensions

Length____	84 inches
Width____	32 inches
Height____	68 ¼ inches

Operating Requirements

Fuel Type____	Natural Gas
Temperature____	0 degrees F to 104 degrees F

Outputs

Power Output ____	5kW
Voltage ____	120/240 VAC @ 60Hz
Noise ____	< 70 dBA@ 1 meter

Certifications

CSA International____	Fuel Cell System
UL1741____	Power Conditioning Module
IEEE P1741	Grid Parallel Generation

Figure 8, Product Specifications

Installation Application

Figure 7, above, describes a one line diagram of the Fort McPherson fuel cell installation. The diagram illustrates utility and control interfaces including, gas, power, water and instrumentation devices installed in both the residential equipment room and the exterior equipment chest at the Luster residence. Figure 8, above, lists the specifications of the Plug Power GenSys5C PEM technology demonstration fuel cell chosen for this site.

The electrical conduit runs between the facility load panels and the fuel cell are approximately 40 feet. The Reverse Osmosis/DI water tubing run that provides filtered process water to the power plant is approximately 10 feet distance, and the thermal recovery piping runs between the fuel cell and the hot water heater is also approximately 40. Fuel Cell waste heat flows to a Heliodyne heat transfer coil that maintains the domestic hot water tank at 130 degrees F, which should be adequate to meet the domestic hot water demand of the facility. (Figure 5)

The fuel cell inverter has a power output of 110/120 VAC at 60 Hz, matching the building distribution panel in the mechanical room with its connected loads at 110/120 VAC. The installation includes both a grid parallel and a grid independent configuration as indicated in Figure 5. The unit provides stand-by power to a new 100amp critical circuit panel that serves several kitchen appliances and other plug loads. A two-pole wattmeter monitors both the grid parallel and grid independent conductors to record fuel cell power distribution to both the existing panel and the new critical load panel.

LOGAN connected the fuel cell gas piping into the existing service line adjacent to the fuel cell pad, and installed a gas meter to calculate fuel cell usage as indicated in Figure 4, above. A regulator at the fuel cell gas inlet maintains the correct operating pressure at 14 inches water column.

A phone line connection with the fuel cell modem provides communications with Plug Power and LOGAN customer support functions.

The installation proceeded according to plan with minimal inconvenience to the base or the host site.

Permitting

LOGAN worked closely with the Fort McPherson Environmental Department to insure the installation satisfied all environmental requirements. No permits were required or issued for this site.

Start-up and Commissioning

At the time of the first start on Oct 31, 2003, LOGAN's technician performed the prestart items covered in Figure 9, below, and the commissioning checklist covered in Figure 10, below. Operations testing and tuning of the fuel cell's electrical and mechanical systems will continue to insure smooth and reliable performance. With the connection of the Ethernet service on January 14, 2004 the unit became fully operational.

Service incidents and facility calls will be reported on the sample Service Call Report form listed below as Figure 11.

An Economic Analysis of the Robins AFB project appears in Figure 12 below.

Installation Check List

TASK	SIGN	DATE	TIME(hrs)
Batteries Installed			
Stack Installed			
Stack Coolant Installed			
Air Purged from Stack Coolant			
Radiator Coolant Installed			
Air Purged from Radiator Coolant			
J3 Cable Installed			
J3 Cable Wiring Tested			
Inverter Power Cable Installed			
Inverter Power Polarity Correct			
RS 232 /Modem Cable Installed			
DI Solenoid Cable Installed with Diode			
Natural Gas Pipe Installed			
DI Water / Heat Trace Installed			
Drain Tubing Installed			

Figure 9, Installation Check List

Commissioning Check List

TASK	SIGN	DATE	TIME (hrs)
Controls Powered Up and Communication OK			
SARC Name Correct			
Start-Up Initiated			
Coolant Leak Checked			
Flammable Gas Leak Checked			
Data Logging to Central Computer			
System Run for 8 Hours with No Failures			

Figure 10, Commissioning Check List

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Service Call Report

SERVICE CALL REPORT

System Serial #:__________________________

SYSTEM INFORMATION

Date:______________________________

Purpose of Service Call ☐Repair ☐Maintenance ☐ECN (Check all that apply)

	Date	Time
Date/Time shutdown	____________________	____________________

MAINTENANCE / REPAIR INFORMATION

Service Tech Name:

Travel Man-hours:

Troubleshooting Man-hrs:

Repair Man-hours:

Spare Part Delay Time:

Work Performed:

Technician

Comments:

FAILURE REPORT SUMMARY

Date	Description of Problem	Rpt #	Initials

Figure 11, Service Call Report

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FY' 02 RESSDEM
Fort McPherson PEM Fuel Cell Economic Analysis

Estimated Project Utility Rates	
1) Water (per 1,000 gallons)	$1.69
2) Electricity (per KWH)	$0.0651
3) Natural gas (per MCF)	$5.25

Estimated First Cost	
Plug Power 5 kW SU-1	*$65,000*
Shipping	*$1,800*
Installation electrical	*$1,250*
Installation mechanical	*$3,200*
Watt Meter, Instrumentation	*$3,150*
Site Prep, labor materials	*$925*
Technical Supervision	*$8,500*
Total	***$83,825***

Assume Five Year Simple Payback	**$16,765**

Forcast Operating Expenses	**Volume**	**$/Hr**	**$/ Yr**
Natural Gas			
Mcf/hr @ 2.5kW	*0.032838*	*$0.17*	*$1,359*
Water			
Gals/Yr	*4918*		*$8.31*

Add Total Annual Operating Costs	**$1,368**
Total Annual Costs (Ammortization + Expenses)	**$18,133**

Economic Summary		
Forcast Annual kWH	*19710*	
Annual Cost of Operating Power Plant	*$0.0694*	kWH
Credit Annual Thermal Recovery	*-0.016489*	kWH
Project Net Operating Cost	*$0.0529*	kWH
Ammount Available for Financing	*$0.0122*	kWH
Add 5 Yr Ammortization Cost / kWH	*$0.8506*	kWH

Current Demo Program Cost Assuming 5 Yr Simple Payback	**$0.9200**	**kWH**

***NOTE**Does not include allowance for cell stack life cycle costs or service over 5 year economic senario*

Figure 12, Economic Analysis

Project Contacts

1. Project Manager: Sam Logan
   LOGANEnergy Corp.
   866.564.2632
   samlogan@loganenergy.com

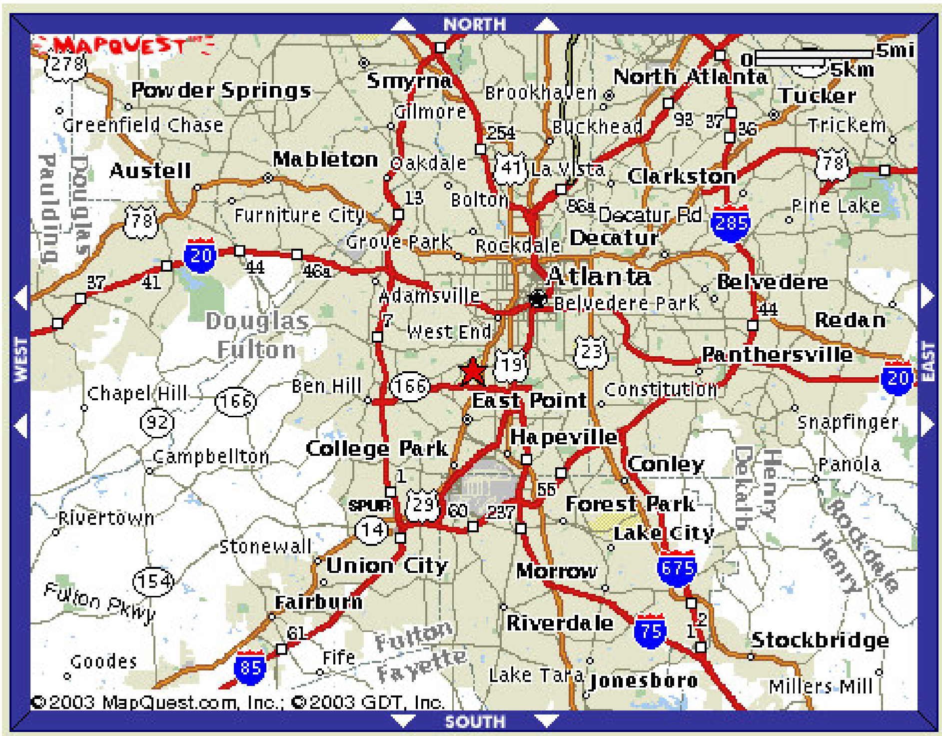
2. Field Engineer: Mike Harvell
   LOGANEnergy Corp.
   803.635.5496
   mikeharvell@loganenergy.com

3. Fort McPherson POC: Luke Wyland
   404.469.3563
   Luke.Wyland@forscom.army.mil

4. Plug Power: Scott Wilshire
   Plug Power, Inc.
   968 Albany Shaker Rd.
   Latham, NY 12110
   518.782.7700 ex1338
   Scott_Wilshire@plugpower.com

Figure 13, Project POC s

Site Location



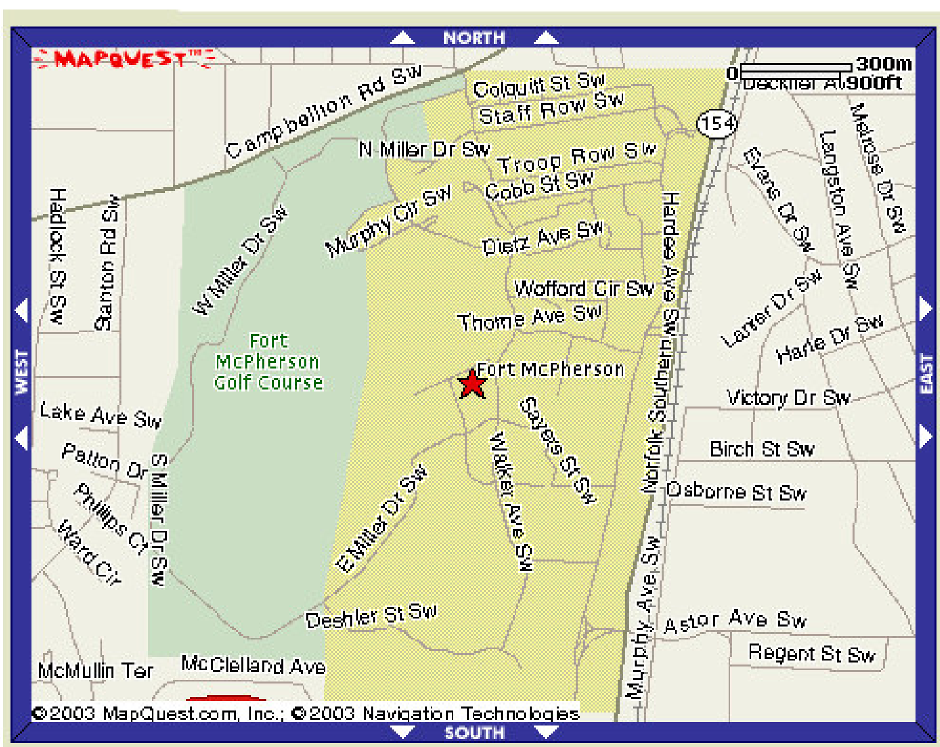


Figure 14, Fort McPherson Location

Installation Safety Plan

Project Description	Activity Date
Ft McPherson Fuel Cell Demonstration Project...Electrical and Mechanical Installation and Thermal integration of Plug Power GenSys5C 5kW PEM Fuel Cell Power Plant .	Months of October/November 2003

Installation Site	Project Manager	Prepared By
1540 Miller Drive 532Q Fort McPherson, GA	LOGANEnergy Corp. 1080 Holcomb Br Rd 100 Roswell Summit, Suite 175, Roswell, GA 30076	Samuel Logan, Jr. **Date** 01/15/04

Project Personnel

Ft. McPherson Project Mgr.	LOGAN Project Manager/Representative	Emergency Medical Response
Luke Wyland (404) 469-3563	**Name** Mike Harvell (803) 635-5496	**Grady Memorial Medical Center**

Project Contractors	Other Personnel	Specialized Equipment for Tasks
Shiflett Electric 404-753-6104 Milo Plumbing 803-732-0177	Luke Wyland, Ft McPherson Public Works 678-283-6608	Fork Truck, Thermal Welder, Power Drill, Various Power Tools

Installation /Construction

Tasks	Perils	Mitigation
1. Hand Trench 50 feet 1/2" NG Line	Cut/damage other buried utilities, conduit, lines	Locate and Mark buried utilities before trenching.
2. Hand trench 150" water line.	Cut/damage other buried utilities, conduit, lines	Practice correct tie-in techniques, use trained personnel.
3. Offload 2,200 PEM Fuel Cell	Damage Equipment, harm/injure personnel.	Use trained equipment operators with trained observers.
4. Electrical/Mechanical Installation	Electric Shock to personnel. Injury or harm working with power tools.	Use "LOTO" procedures; avoid working "HOT" circuits Use trained personnel on all installation tasks.
5. Initial Start of Equipment	Damage Equipment, harm/injure personnel.	Use factory trained personnel, follow procedures.
6. Maintain General Site Conditions	Unkempt Site...Danger to residents and visitors.	Remove loose materials, tools, police site at end of each day. Place yellow caution ribbon around installation/work areas.
7. Maintain Safe Work Environment	Injury, loss of equipment, materials, customer dissatisfaction, loss of time and money.	Manager's Representative to encourage safe practices by all contractor personnel; critique unsafe practices; and lead by example.
8. Personnel Safety	Head, hand and foot injury.	Construction/installation crews shall wear appropriate personal protective gear while performing job site tasks.